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Study of Hybrid Optical Amplifier for WDM Systems

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Abstract—*The transmission capacity can be enhanced by increasing the number of channels in a communication fibre link. Due to more channels, the system becomes more vulnerable to non-linear effects due to higher power coupled to fibre link. A possible way to avoid the nonlinear effects in this case is spreading the input channels throughout the available amplification bandwidth in order to enlarge the channel spacing as the bit rate increases. With the purpose to operate this wide bandwidth applying WDM transmission it is suitable the use of hybrid amplifiers. In this paper, the hybrid optical amplifier is designed that consists of amplifiers i.e. EDFA and RAMAN amplifier. Two types of hybrid optical amplifier is considered depending on the positions of EDFA and RAMAN amplifiers i.e. Type - A and Type – B. The performance of this system is evaluated in terms of Gain, Noise figure.*

Introduction

The revolutionary growth in Optical communication network for its enormous capacity and low transmission loss, leads to development of powerful optical amplifiers, which eliminate the need for costly conversions from optical to electrical signal and vice-versa.

Erbium doped fibre (EDFA) [3], an amplifier renowned for its ability to produce significant gain under low pumping power. The integral component of the EDFA is the erbium doped fiber (EDF), a versatile gain medium which has also been utilized in erbium doped fiber laser design [4]. Efficient EDFA pumping is possible using semiconductor lasers operating near 0.98 µm and 1.48-µm wavelengths.

Similarly, great attention has been paid to the Raman fiber amplifiers (RFA) used in conjunction with EDFA's to form hybrid amplifiers, especially when the system capacity needs to be upgraded by raising channel speed and spectral efficiency without bandwidth expansion [4]. The success of C and L band WDM systems is attributed to several unique features of EDFA's. These include high gain, polarization independence, low noise figure, and a long upper-state lifetime, making EDFA's ideal for WDM systems. Discrete Raman amplifiers can be made with similar unique characteristics even at wavelength bands outside the C- and L-bands, thereby opening up wavelength bands outside the erbium window for WDM transmission [5].

So, after the entire C-band is fully utilised, L-band amplification is extensively studied. To obtain composite C + L EDFAs, there are several issues which make system expensive. Therefore, there is need of Hybrid amplification due to: (i) RFA with lower NF than the L-band EDFA are recognised as a potential player. So, to achieve a higher gain with lower noise figure or a wider amplification band is to use an EDFA in combination with a distributed Raman amplifier (DRA). Thus, a hybrid C + L-band EDFA/RFA is a promising technology for WDM systems, (ii) the gain spectrum of DRA can be vary by adjusting the pump powers and pump wavelengths. So this property is used to increase the amplification bandwidth of EDFA [2].

In this paper, the EDFA is positioned before RAMAN amplifier is Type-A and if EDFA is positioned after is Type-B [6]. Depending on the positions the Gain is determined.

This paper is divided into four sections i.e. Introduction, Design, Results and discussion and Conclusion.

Design of Hybrid Optical Amplifier

Each transmitter section consist of data source, electrical driver, and Continuous Wave (CW) laser source and mach-zehnder modulator. The data source is NRZ format at 10 Gb/s as shown in fig. 1. The continuous wave laser source generates the laser beam at 1550 nm. The input data source modulates at laser beam using a mach-zehnder modulator. The output of modulator is fed to the optical link consist of single mode fibre, dispersion compensated fibre and RAMAN-EDFA hybrid optical amplifier.

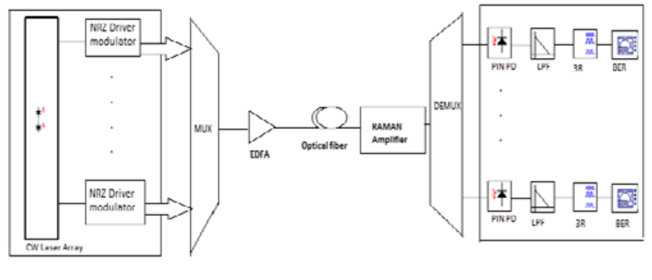

Fig. 1: Hybrid optical Amplifier (Type A)

As shown in fig. 1, EDFA is placed before RAMAN amplifier i.e. Type A. In fig. 2, EDFA is placed after RAMAN amplifier its Type B.

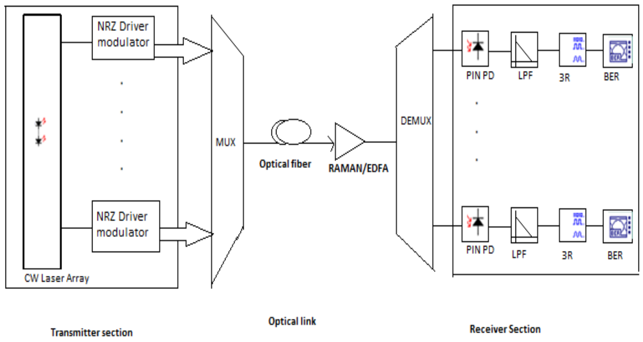

Fig. 2: Hybrid optical Amplifier (Type B)

Results and Discussion

In this model EDFA and RAMAN amplifier is used. The RAMAN amplifier consists of 25 km fibre length co-directionally pumped having pump wavelength 1450 nm and pump power 310 mW. The length of the single mode fibre (SMF) is 100 km.

The dispersion compensation fibre (DCF) is used for the dispersion compensation and to increase the transmission distance.

The equation for determining the length of compensating SMF was found in Aggarwal [1] as:

$$L_2 = -\left(\frac{D_1}{D_2}\right) * L_1 \quad (1)$$

where L_1 and L_2 are the lengths of SMF and DCF respectively and D_1 and D_2 are the dispersion parameters for SMF and DCF respectively.

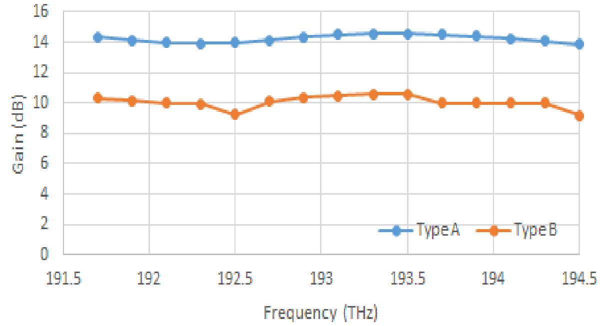

Fig. 3: Gain v/s Frequency

In fig. 3 the Gain is plotted for type A and type B. Type B shows the Gain of 15 dB and type B shows the Gain of 11 dB. So, Type B performs better than Type A.

The noise figure for Type A and Type B is shown in figure 4. For Type B noise figure is 9 dB and for type B noise figure is 5 dB.

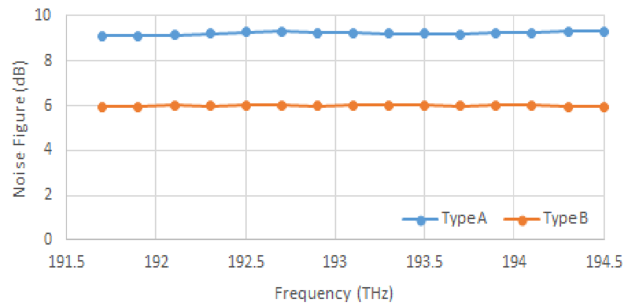

Fig. 4: Noise Figure v/s frequency

Conclusion

The investigations shows that the hybrid optical amplifier performs better if EDFA is positioned after RAMAN amplifier. As shown in results Type B performs better than Type A.

So, the hybrid optical amplifier enhances the Gain over different frequency range.

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